

IMPROVEMENTS IN AND RELATING TO SURVEILLANCE SYSTEMS

This invention relates to the field of surveillance, and more specifically, but not exclusively to surveillance based systems which utilize intelligence of knowledge based systems to support their operation.

Improvements in the art of closed circuit image acquisition cameras have provided for a marked increase in the use of remote cameras for applications such as shop and public area security and more evidently traffic monitoring and law enforcement.

Typically, the type of camera systems utilised for shop and public area security fall into two main categories, namely the fixed field of view, fixed focus real time recorded video system, and the more labour intensive human operated system, usually comprising an operator directable and focusable camera assembly.

Law enforcement applications for camera systems typically comprise either a similar type operator based system as described above for traffic monitoring, or fixed position speed cameras, which utilize a radar based object speed detection sensor and timing unit to capture images against fixed references to allow for subsequent human analysis for the purpose of court evidence. Increasingly the use of digital camera technology is providing for more sophisticated vehicle speed analysis cameras, but typically such systems are mobile and require a human operator.

In an attempt to provide the police with greater information about the movement of vehicles around the UK road system, tracking systems have been proposed which utilize camera systems that effectively capture and analyse images of passing car registration plates. The information captured is relayed to a central unit, the information then being searchable so as to allow the selective identification of a known vehicle's movements.

One common problem encountered in the art is that of the amount of data which is required to be stored to enable meaningful post analysis of the

captured scene. Data compression techniques have been applied such as the storing of only every fourth video image frame, but this leads to the step animated appearance of some surveillance system image playback.

A further problem associated with surveillance systems is the quality of images and information discernible from such images that are captured and stored. The requirement to have a field of view camera or other imaging means sufficient to cover a whole scene usually dictates the use of low resolution, wide-angle equipment. Evidence of the poor quality images usually associated with surveillance systems can be illustrated by the footage produced from security systems such as those used in high street banks and petrol stations. Often the facial features of criminals are difficult to identify using the results of such systems, even when the criminal is captured facing directly at a camera.

Our invention provides for surveillance and monitoring system which comprises the ability to combine state of the image capture technology and real time scene and image analysis, with an intelligent, knowledge based system. This results in a surveillance system which requires minimum operator intervention to provide an intelligent assessment of captured real time events, and further provides for the ability to prompt an operator or initiate certain control functions on the witnessing of some pre-determined event or series of events.

Accordingly there is a surveillance system comprising imaging means, said imaging means being positioned so as to have a field of view of an area over which surveillance is required, image processing means, said image processing means being programmable such that an operator can pre-determine the events which activate use of image analysis means, image analysis means, said image analysis means utilising processing means to determine suitable control function responses to events viewed by said imaging means, and system control means, said system control means providing general control functions to said imaging means, scene processing means and scene analysis means.

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In yet a further embodiment of the invention, said image analysis means comprises an artificial intelligence (AI) means, said AI means providing for increased selectivity in the choosing of target objects and patterns of events, thereby further reducing the level of data storage or compression required for operation of said surveillance system.

Figure 1 is a schematic representation of a surveillance system in accordance with the invention.

Figure 2 is a diagrammatic representation of a scene captured by said first and said second cameras.

Figure 3 is a diagrammatic representation of a network of cameras in accordance with the invention.

Figure 1 shows a surveillance system 1 in accordance with the invention in which an imaging means 3 comprises two charged couple device (CCD)

cameras 2 & 4. Camera 2 comprises a wide to normal field of view low to normal resolution CCD camera, whereas in comparison to camera 2, camera 4 comprises a narrow field of view, higher resolution camera. Camera 4 may further comprise a zoom facility and may or may not be aligned to the boresight of camera 2. Cameras 2 and 4 may also be provided with dependent or independent controllable movement and rotation about a range of axis to further facilitate the possibility of acquiring an image for analysis.

Additionally cameras 2 and 4 may comprise, but are not limited to, discrete camera systems, multiple lenses or multiple mirror systems or adaptive optics systems, which may be co-located, widely spaced or be part of a multiple camera application.

The outputs of cameras 2 and 4 are fed to the image processing means 8 via a system control means 6. The image processing means 6 provides the first level of image analysis by processing the images captured by said camera 2 and determining whether further analysis of the image is required by reference to at least one database means 12. The image processing means will have been pre-programmed to be triggered into requesting further analysis of an image or images on witnessing certain pre-determined events, features or sequences of actions or images. The pre-determination of these events etc may require the use of and access to a range of data-base means, possibly via a hub means 10, including, but not limited to, human operators, Rule Based Systems (RBS), Knowledge Based Systems (KBS), Artificial Intelligence Systems (AI), Data-Bases, Algorithms and the like.

Examples of images or events which may form the basis of a pre-programmed trigger to request further analysis include the speed, dimensions, temperature, luminescence, time, frequency of passing, conformity or abnormality of human beings, animals, vehicles or other defined objects.

Additionally the image processing means may make a qualitative assessment of the image provided by camera 2, and should the threshold quality of the image not be provided by camera 2, then the image processing means will request from the system control means 6 that the second camera 4

be used so as to provide higher quality images for passing to the image analysis means 14. The assessment of the adequacy of the image to ensure sufficient characteristics have been captured will ensure the increase in certainty of recognition required for evidence purposes in criminal prosecutions.

Additionally the image analysis could be utilised to monitor patterns of behaviour of individuals or groups of individuals for the purposes of marketing and/or sales or customer/product intelligence.

The image analysis means 14 provides the surveillance system 1 with the ability to make a detailed analysis of the content of images supplied by cameras 2 and 4, such analysis being provided by access to a range of data-base means 18, in a similar fashion to that described above in connection with said image processing means. The image analysis means 14 is shown having a hub connection 16 to a range of data-base sources 18, which may include, but are not limited to human operators, RBS, KBS, AI, Data-bases and Algorithms and the like. The various database means available to the image analysis means may or may not include those database means accessible by the image processing means.

The image analysis means will have the ability to demand further image information, such information comprising higher or lower resolution images from cameras 2 and 4 or wider angle images along with use of additional imaging means such as, but not limited to, conventional radar, synthetic aperture radar (SAR), infra-red imaging systems (visible and non-visible), millimetric wave imaging systems, acoustic and magnetic systems.

Operator defined criteria will define the images which will be selected for image analysis 14. The nature and extent of the image analysis conducted will depend on the functionality of the particular surveillance system and it's constitute components. Examples of the extent of image analysis include the facial identification of human beings, with possible cross references to databases of known criminals, suspects or other persons whose whereabouts is required to be established, car registration analysis, with cross references to

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details such as vehicle colour, speed, location, occupants, frequency of passing a known location, or time spent within a particular catchment area.

The image analysis function of the surveillance system is designed to include an element of 'self-learning' or AI which will provide for the establishment of pattern or behavioural analysis. Such analysis will provide for an effective filter mechanism to eliminate from further analysis activities or patterns of behaviour which it has been previously established are not worthy of further analysis, for example, the same car seen every Wednesday at 5:00pm, to 5:30pm, the same two men enter the building society carrying bags every Friday, a person of the same dimensions passes wearing a crash helmet every day.

The use of the image analysis means 14 combined with the other elements of the system will enable the identification of discrete features or known patterns of behaviour which differ from the established norm, or may warrant surveillance on the basis of matching with the identification of a particular person, object or combination thereof.

The system control means 6 provides the surveillance system 1 with control functions required to administer the operation of the system as a whole, and may include, but are not limited to self diagnostic functions (image quality, system functionality, communications integrity etc), alarm functions relating to unlawful interference with the system and control of the imaging means by functions such as managing requests from the image processing means to switch or alter characteristics or functions of the imaging means (i.e. direction, focus, lens, resolution, type of camera etc). Additionally the system control means may control and/or manage the communications links to the various external bodies, databases, establishments or persons required by the type of operation to which the system is being put to use.

Figure 2 shows an example of a scene as may be viewed by an imaging system 2 & 4 as described above. The extent of the viewable image is shown 24, the view comprising a section of highway 28 and an area of public walkway 40. A car 26 is shown passing through the scene 24, and in this example of a

surveillance system in accordance with the invention, a trigger has been pre-programmed within the image processing means 8 such that when a car passes through the scene 24, the image analysis means 14 is activated and certain information is sought for further analysis.

In the car 26 passing through the scene 24, the image analysis means would typically be programmed so as to try and acquire positive identification of the numerals displayed on the vehicle registration plate 32. Should the image supplied by the camera 2 not provide sufficient clarity or contain sufficient information for such data to be acquired, then the image processor means will request, via the system control means, that a higher resolution camera means 4 is used, giving more detailed information relating to one area of the scene 24. In this example, frame 30 shows a representative fields of view for camera 4, the information contained therein being sufficient for the image analysis means 14 to make a positive identification of the vehicle registration plate. Once the image has been acquired, the image analysis means 14 can connect via the hub 16 to a database of known vehicle registrations, and if required can store or supply information relating to the said vehicle to another database or to any other type of display of data storage means. Additionally, other databases may be interrogated so as to provide further identification features such as the cross matching of the vehicle colour to that on the registration details, cross referencing the registration to vehicles reported stolen or the owners of which are required for questioning by the police or insurance companies, along with other possible checks such as vehicle speed, frequency of passing a certain location and elapsed time spent within a certain vicinity.

The system can further utilised for example to acquire images of vehicle occupants. Frame 34 depicts the field of view of camera 4, giving a view of the occupant of the vehicle. The image can then be interrogated by reference to a facial identification database (i.e.18) , which again may be further interfaced to additional databases and/or RBS, KBS and AI systems to enable the identification and knowledge of the movements and type of transport used by specific persons or groups of persons.

Figure 2 also depicts a view taken from an imaging means 2 showing a group of people 44 walking along a pathway 40. One of the pre-determined triggers for the image processing means 8 could be the recognition of 'human shaped objects' 44. The image analysis means would then be tasked with identifying the face of the human being by applying the use of camera 4 and frame 46. In the event that the face of the human could not be identified due to obscuration by means such as a hat 42 or balaclava (not shown), the image analysis means would record a failure to identify a target and depending on the nature and extent of the rules governing the database means may either raise an alarm to an operator, or begin a further sequence of analysis to try and further identify characteristics of the subject. Such further analysis could extend to identifying objects 50 carried by the subject, and by applying the use of higher resolution camera means 4, using field of view frame 48, the image analysis means will attempt to identify the object 50 by reference to a list of known threats, i.e. firearms, truncheons, knives etc. Depending on the result of the analysis, images may be stored and/or operator alarms maybe activated or other control functions initiated such as alarms, door closures, lighting increased and the like.

Figure 3 shows a network of surveillance systems 52,54,56,58, in accordance with the invention. Each of said individual surveillance systems 52,54,56,58 can operate in accordance with the system described in figure 1, each having imaging means 2, 4, system control means 6, image processing means 8, image analysis means 14, hub means 10, 16 and database means 12, 18. Additionally there is provided a master system control means 62, master image processing means 64, master image analysis means 66, and corresponding hub means 68, 70 and database means 72, 74. The master elements of the system 62, 64, 66 as depicted in figure 3, enable the surveillance system as a whole to be centrally managed or controlled to enable more sophisticated surveillance tasks to be undertaken. A typical connectivity is illustrated between the elements of the networked system, but various combinations or interface means may be provided between said elements such

as databus technology, digital or analogue cable or terrestrial transmissions or satellite communications.

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Utilising the invention in the embodiment shown at figure 3, if image analysis means 6 comprising a camera acquires an image which is passed by the image processing means 8 to the image analysis means 14, then should said image move out of view of the system 52, then via the master system control means 62, the imaging means of system 54 can be employed to continue the surveillance and analysis as required. This 'hand-over' between the individual elements of the networked system provides for a far greater area coverage than the individual system, and additionally provides for ensuring the continuity of surveillance required for evidence in criminal prosecutions.

Alternatively, in an embodiment not illustrated, the surveillance system may be provided with a system control means and/or a master system control means which is provided with a plurality of imaging means connected to directly to said master or system control means, thereby providing for the centralising of the control functions of the system, and the probable reduction in the number of image processing and image analysis means required to perform the surveillance operation.

The imaging means 3 provided for use with the system may be mobile, or connected or installed on a mobile platform or vehicle.

The system as a whole may itself be self contained such that references to databases should be interpreted as references to algorithms contained in or accessible by the system. Such self contained systems may make use of mobile or fixed cameras but be self contained in the sense of no communications to databases outside of the system.